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ALSO SOME SAFETY PRACTICES AT THE MONTREAL MINE

BY

F. S. CRAWFORD AND C. W. OWINGS

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ELECTRICAL BLASTING IN SINKING MONTREAL NO. 5 SHAFT; ALSO SOME SAFETY PRACTICES AT THE MONTREAL MINE[1]

By F. S. Crawford[2] and C. W. Owings[3]

Interesting data on electric blasting and sinking of the Montreal No. 5 shaft of the Montreal Mining Co., Montreal, Wis., were obtained during the sinking of the last 877 feet of this shaft. Several unusual features and safety practices are also to be found in the Montreal mine.

The Montreal shaft was sunk 2,156 feet from August 16, 1921, to May 1, 1924, and 877 feet from October, 1927, to June, 1928. The first section of the shaft was supported with steel sets spaced 5 feet on centers; and instead of lagging the walls were covered with three-eighths of an inch of gunite where greenstone was encountered, and where quartz-slate was found (from the surface to the 12th level) the walls were lagged with tamarack lath treated with carbolineum, a preservative.

In October, 1927, when the last sinking program was started, the bottom of the shaft was 120 feet below the 27th level. An opening large enough to accommodate the pipe and ladder compartments, each 3 ft. 8 in. by 5 ft. 2 in., was sunk 18 feet to provide for a pentice, and the shaft was then widened to the full section, 19 by 12 feet. The pipe and ladder compartments were inclosed from the pentice to a point about 70 feet above the 27th level by lagging between the cage and skip compartments and the pipe and ladder compartments. A solid inclined timber bulkhead with rails on top was built over the pipe and ladder compartments, primarily as a protection against the counterweight for the cage, the counterweight being in a 12-inch pipe in the pipe compartment.

The company designed a crosshead cage equipped with a metal roof and a riding platform. Safety catches were provided to engage the guides when the weight of the crosshead was not supported by the bucket. The crosshead traveled in the shaft with the bucket, except for the distance from the last set to the bottom of the shaft. Water lines carried water to the machines for use in drilling.

A fan placed on the 27th level ventilated the bottom of the shaft through a 12-inch galvanized iron pipe, which was kept within 40 to 60 feet of the bottom of the shaft. It

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1 "Reprinted from U. S. Bureau of Mines Information Circular 6189."

2 District engineer, U. S. Bureau of Mines.

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was necessary to keep the pipe this distance from the bottom in order not to damage it during blasting. A 200-watt light with a large reflector was hung from the last steel set; the light line was a 2-conductor Tirex cable. A main switch was placed on the 27th level so that power could be cut off the whole line during blasting.

For signaling from the bottom of the shaft to the brakeman a standard electric pull switch was installed at the collar in the sinking compartment, and to the handle of this switch - a three-sixteenths-inch flexible galvanized wire cable - was attached and hung down the shaft to the bottom. The weight of this pull cord was taken by an extra spring. By using a pull cord signals could be rung from any part of the shaft. No electric current was used for signaling below the collar of the shaft.

A ladder 50 feet long, of three-eighths-inch wire cable with metal rungs, was hung from the last set of timbers to the bottom, so that in case of power failure or other difficulty the men could climb up. The mucking was done with long-handled shovels, and the miners were supplied with two pairs of canvas gloves a week. As a safety precaution the men wore "hard-boiled" hats while working in the shaft.

DRILLING

Hand-held drilling machines were first used, but they proved to be so fatiguing that mounted machines were adopted. The hand-held machines were capable of drilling 1 to 3 inches per minute and the mounted machines drilled 3 to 5½ inches per minute. The drill steel was 1¼-inch round lugged steel with a cross bit. A 10-inch run was made before changing drill steel; the first drill was 2½-inch gauge and the last drill was 1½-inch; that is, the gauge decreased about ⅛ inch for each change in drills.

The average time for rigging up was 1 hour 45 minutes, including lowering and placing two bars with necessary blocks and wedges, eight arms, eight clamps, eight machines, eight water hose, eight air hose, two blow pipes with hose, two air manifolds, and one water manifold; hanging two armored hose from pipe connections; hanging four plumb lines in the corners of the shaft; and lowering a supply of drills, wrenches, etc.

The average time taken to drill 42 holes in the shaft was 7 hours 15 minutes. A "V" cut was drilled in the center of the shaft, with a row of 6 holes on each side. Three additional rows of holes were drilled at each end of the shaft with 5 holes in a row. Cut holes were 7½ feet and side holes 7 feet deep; the average depth broken per cut was 6 feet 2 inches. As soon as a machine completed drilling it was taken down and hoisted up the shaft to the 27th level. The average time necessary to rig down and blast was 1 hour 45 minutes.

BLASTING

Before loading of holes was started all electric current was cut off from the shaft. A 60 per cent strength ammonia gelatin dynamite was used in blasting. Delay electric igniters and No. 6 detonators were used to fire the charges. The igniters as purchased

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contained fuse, ranging in length from 2 to 12 inches. In order to cause the holes to fire at different times the fuses were trimmed so that the length of each fuse was about $\frac{1}{8}$ to $\frac{1}{4}$ inch less than the next longer fuse. The object in trimming the fuses was to allow each hole to fire alone in order to prevent a large blast occurring and dislodging or knocking out steel sets. The detonators were attached to the fuse in the underground magazine on the 27th level. Although the drill holes were blown out, before charging the holes were moist and some of them were wet, hence a sealing compound was used to waterproof the delay igniters.

Cartridges were slit and were compressed by pushing them into place with a wooden tamping bar, and a cartridge of clay stemming was placed in top of the explosive in each hole. The "primer" was the second or third cartridge placed in a hole, thereby reducing misfires. An average of 450 cartridges of explosive was used per cut, the high count resulting from having to refire holes that misfired or were cut off due to the presence of numerous fault planes and joints. Misfired shots were dug out carefully until the explosive was reached, another primer was inserted, and the hole refired. No holes were drilled until all misfired shots had been fired. There is no record of accidents from misfired shots.

The lead wires were 22 gauge copper wire 12 feet long, copper covered, both legs black and waterproofed. Before primers were made the igniters were tested with a galvanometer and the wires twisted together, since the lead wires were not short-circuited by the manufacturer. The lead wires were then attached to the blasting-cable wires by twisting them together. The firing line consisted of 1000 feet of No. 14 2-conductor Tirex cord mounted on a reel 18 inches wide and 22 inches in diameter. The reel was equipped with a brake and cable lock, and a short-circuited plug was kept in the receptacle on the reel. This plug was not furnished with the reel but shortly after it was received the plug was made and placed in the reel. The end of the cable was connected to a socket in the reel, but the line and the reel had no electrical contacts until all connections had been made at the bottom of the shaft, and then a short extension cord from the main blasting switch was plugged into the reel and the switch closed.

The blasting switch was a double-throw Trumble safety switch containing a fuse block with two removable fuses, which were kept outside the box and not inserted until just before the blast was fired. Both the metal box and the switch were grounded, and the switch was so placed that when open the switch handle hung down. The power was 220 volts alternating current, 60 cycles. The cable between the reel and firing switch was about 20 feet long, and the gap between the reel and firing switch was more than 6 feet. The blasting cable was reeled in after each blast, and an inspection was made of the cable. Contact was held for only a few seconds.

As the shaft sinking was a continuous cycle of operations the round of holes was fired without regard to shifts in other parts of the mine. All men were hoisted to the 27th level before connections were completed.

The blasting was done in two stages; the cut holes and the holes at one end of the shaft were blasted first, making 27 delayed shots; after the first blast was mucked out the remaining 15 holes were cleaned out and blasted. No combinations of holes were fired

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simultaneously.

The time of mucking an average of 60 buckets of rock averaged five hours 45 minutes after the first blast, and it required about 45 minutes to blow out, charge, and blast the remaining 15 holes. An average of 124 buckets of rock was hoisted after the second blast in about 13 hours 15 minutes. The men were very careful to trim down all loose rock on the sides of the shaft, and as there were many fault planes and joints this required about 1 hour 15 minutes after each blast.

After each blast or each second blast a collar was "hung"; that is, two wall plates and two end plates were placed and suspended by four studdles. When four collars were hung they were lined and blocked into place, and sacks filled with concrete were placed at the corners. When eight sets had been placed the miners gunited the eight sets, taking about eight hours for the task. Bearing pieces consisted of 12-inch I section beams, placed under the end plates and dividers. Eight hitches were cut into the walls of the shaft far enough to obtain a good solid bottom to support the load carried by the bearing pieces. A box was then built around each end of the beam and the whole hitch was filled with concrete, thus making the bearing pieces practically a part of the shaft wall.

VENTILATION

One hour was allowed for ventilation after each blast. The fan was first run exhausting for half an hour, after which the air current was reversed and fresh air blown down. A small amount of compressed air from a ¾-inch pipe was also allowed to blow at the bottom of the shaft for ventilation.

SAFETY IN ELECTRICAL BLASTING

No accidents from electrical blasting were recorded during the period the shaft was being sunk. This may be attributed to the greater control of blasting possible with electrical blasting. The power could be kept out of the firing line at three points and hence there was little likelihood of premature shots. All men were hoisted to the 27th level before power was placed in the blasting line and the shots fired. This gave additional safety to the men. The misfires and cut off holes, occasioned by using fuse with the electric igniters may have resulted in injuries but the care given to this hazard was reflected in the favorable accident record.

GENERAL MINE SAFETY

Fire Protection.- The property is well equipped for fire protection and fire fighting. A volunteer fire department for the city of Montreal is composed of 21 mechanics who work in the machine shop near the municipal fire hall, and a motor-driven fire truck is always in readiness for response to surface calls. Water is available from deep wells, pumped into two tanks, on steel towers, with a combined capacity of 200,000 gallons. Pressure is always maintained in fire plugs located about the town. Freezing is prevented in winter by packing the valves in salt; each fall the cast-iron shells of the fire hydrants

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are filled with coarse salt, and if water enters the hydrant some of the salt dissolves and the resulting salt solution will not freeze at ordinary temperatures. If the hydrant is used during the winter more salt is put around the valves. In the spring the salt is flushed out of the hydrants; and during the four years this system has been tried, no detrimental effects have been noted on the hydrants, and freezing of hydrants has been avoided.

In winter the roads are kept clear of snow by the mining company to facilitate traveling to fires. The fire system is inspected daily. Fifty 2½-gallon soda-acid fire extinguishers are distributed throughout the surface buildings, shops, and shaft stations.

For underground fire protection every air connection is a potential water tap; water and air lines are connected at the shaft stations through suitable pressure-reducing contrivances. Four hundred feet of 1½-inch hose with a ⅝-inch nozzle is kept on the 26th level. The pump discharge water as well as the surface water is available for diverting into the air lines if necessary.

A stench warning is installed at the collar of No. 4, No. 5, and No. 6 shafts. A 1-quart container of ethyl-mercaptan is always kept in readiness at each shaft, ready to be poured into a lubricator attached to the air line. There are no fire doors at present in the mine.

Telephones.- An automatic telephone switching system is provided at the mine; dial switching telephones are located throughout the mine, and they are connected with the office and the residences of officials. This system as installed in the Montreal mine has been successful. An inspection of the exchange apparatus is made each morning by an electrician, for the apparatus is delicate and close adjustment is necessary. A little dust if not noticed in time may prevent operation of the telephones. In the underground telephone boxes there was some trouble at first due to dampness, but by placing a 50-watt electric light bulb in the box and keeping it lighted the heat so generated was sufficient to keep the box dry. A 100-telephone exchange with auto-call and night watchman's service for punching a clock is made part of the system.

Cages.- Men and materials are hoisted in cages; the cage in No. 4 shaft holds 36 men on each of two decks, and the two cages in No. 5 shaft each hold 20 men. Electric hand signals are used while hoisting men and materials, but this signal can not be operated between levels, although it can be operated at levels where the cage is not moving. The cager is responsible for not allowing more than the limit of the number of men to ride on a cage. While ore skips are running only 10 men are allowed on any one cage. Only one light, the cager's, is allowed to be burned on the cage, and this light is hung above the heads of the men being hoisted; all other lights must be extinguished to avoid the danger of fire or clothes being burned. Each man cage is closed by a crimped-mesh wire gate and is provided with hand bars along the sides. The safety chains and catches, with which the cage is equipped, are inspected daily and tested once a month by allowing the cage a free drop of several feet. In most tests the cage is stopped after a drop of only a few inches.

The landing device is unusual. Instead of the land "fans" "dogs" or chairs which

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are recessed in the sides of the shaft and pushed out under the cage when it is desired to support the cage at a landing, the "dogs" are attached to and operated from the cage. The chair arms are cast iron, 3 by 4 by about 18 inches, and are connected to each other and to a control arm by a system of levers. The control arm is placed inside of the cage and is always locked, and the key is kept by the cager. The advantage of this type of chair is that it is always under control of the cage rider and can not be thrown to the landing position except by him when on the cage; where the cage stops at a number of landings it is not necessary to have chairs at each landing.

In No. 5 shaft from the surface to the 12th level the sides are lagged with tamarack lath treated with carbolineum, a preservative. It is planned to replace the tamarack with concrete laths to render the shaft fireproof throughout. Steel ladderways are maintained at each shaft. The new shaft stations are either cut into the solid rock or concreted to render them fire resistant. The skip compartment at shaft stations is entirely inclosed to protect men from falling ore. The stations are kept clean and are painted; and drinking water, piped to the stations from the surface city water supply, is available at sanitary drinking fountains. All electrical equipment and wiring is well installed and operated with due regard to safety and prevention of fires.

Haulage.- Haulage is effected with trolley locomotives and steel side dump cars, which are hauled in trips of five. The cars have no brakes and are equipped with one-half-size Alliance automatic couplers similar to those used on railroad cars. Trouble was experienced with these automatic couplings because of wear, due to the abrasive character of the water and ore dust mixture, which found its way into the couplings. The trouble was overcome by building up the worn places with "steelite," a wear-resistant alloy, which was fused into the body of the draw bar and machined to the original size of the bar. A bell is kept on the rear of the trip of cars as well as on the locomotive to warn persons of approaching trips of cars. Sufficient clearance is provided in most cases to allow a man to pass cars or locomotives, but as an additional precaution shelter holes are made in the sides of the drifts about 100 feet apart, with a green light to indicate the location of the holes.

Trolley wire is guarded at the ore-loading chutes, manway crossings, and stations, usually by a box inclosure that completely incloses the trolley wire, except when a trip is passing. One type of boxing consists of a box 8 inches square. The top of the box fits above the trolley hanger; and the bottom board, which is under the wire, is split longitudinally in the center the full length of the guard, and each section is firmly attached to the side board. The sides are hinged at the top, so that when the trolley wheel enters the box each bottom section and the side piece to which it is attached are forced apart, allowing the trolley wheel to remain in contact with the wire. When the locomotive has passed the box automatically closes. At the end of the boxing the bottom board sections are tapered for about 1 foot from the sides to the center, forming a "V"-shaped opening, thereby allowing the trolley wheel to spread apart the two sides of the box. Another type of box that has proved successful is rigid on the top and sides, but the bottom board is hinged by iron straps that are fastened to the under side of the bottom board, then pass up the side board (but not fastened to it), and are hinged on the top of the box. The bottom board is tapered at each end from one side to a point about 1¼ feet from the end on the opposite side, the taper thus formed allowing the trolley wheel to force the board

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aside while passing through the guard, but allowing the guard to close automatically after the locomotive has passed. These guards are of exceptional merit and afford unusual protection where men must work near or pass under trolley wire.

Ventilation.- Natural draft is relied upon for the main current of air, the velocity being high in cold weather, but low in warm weather. Two blower fans are used in dead ends, where greater attention to ventilation is necessary. Doors are used to control the air current in the winter when the air velocity is high. Old workings near the shafts are sealed, in some instances with gunited board stoppings and in others with check doors. The company has been considering the advisability of installing mechanical ventilation and has put an assistant superintendent in charge of ventilation. Although the ideal location for a fan is on the surface, the greater expense as compared with underground installation did not seem to justify a surface installation at the Montreal mine, and hence the proposed fan is to be placed at the foot of No. 5 shaft, which is to be the intake airway.

Safety.- A general "get together" meeting is held monthly, at which meeting safety subjects are discussed and entertainment is provided. Once a week the mine officials hold a safety meeting, when safety subjects are considered and unsafe conditions and practices are discussed. In addition to the local safety meetings a general staff safety meeting is held monthly at the headquarters of the Ogleby-Norton Co., who operate the Montreal mine, at Ironwood, Mich.

A medical examination is given to all applicants for employment, and plans are now being made to give every employee an additional yearly health examination. The object of this examination is to discover any health conditions that require further attention; to assist the employees to retain their best state of health and efficiency; and, if their health is found to be imparied, to safeguard them from danger by transferring them to a job better suited to their physical condition.

Whenever a department operates for 30 days underground or 40 days on the surface without a lost-time accident, the men are given cigars, a dinner, or other suitable reward. The safety engineer endeavors to obtain definite information on all near accidents, as a hazard exists even though no accident actually occurs, and by removing hazards brought to the attention of the safety engineer by near accidents it is confidently expected that the number of accidents will be decreased.

The lost-time accident record of the company at the Montreal mine from 1924 to 1928 inclusive is given in the table following:

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Montreal Mine Accident Record

Year	Noncompensable accidents	Compensable accidents	Fatal accidents	Total lost-time accidents	Total no-lost-time accidents	Total no. of accidents
1924	13	138	1	152	—	—
1925	30	116	4	150	—	—
1926	120	82	4	206	306	512
1927	17	21	3	41	301	342
1928	1	13	4	18	258	276
Ave.	36	74	3	113	288	377

It will be seen that in the years 1927 and 1928 the lost-time accidents decreased decidedly and the no-lost-time accidents decreased gradually. The accidents in 1928 are especially worthy of note, as the noncompensable accidents were reduced to 1 as compared with a 5-year average of 36; the compensable accidents were 13 as compared with an average of 74; the fatal accidents showed no decrease, but the total of lost-time accidents was 18 as compared with an average of 113 for the 5-year period. During the 3-year period 1926 to 1928 records were kept of accidents that occasioned no lost time. In 1928 the accidents of this class amounted to 258 as compared with 288, the average for the 3-year period. It will be seen, therefore, that the greater attention given to safety is reflected in reduced number of accidents. The general care given to the general safe operation of the mine is responsible for the results obtained.

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